

CLAIMS

1. A fuel cell power system comprising:

a fuel cell configured to generate electrical energy;

switch mode power conditioning circuitry configured to electrically condition the electrical energy generated by the fuel cell, wherein the switch mode power conditioning circuitry; and

a controller configured to monitor an electrical status of the fuel cell and to adjust the conditioning of the electrical energy using the switch mode power conditioning circuitry responsive to the monitoring, wherein the controller is configured to provide a pulse width modulated control signal to control the switching of the switch mode power conditioning circuitry and to vary a duty cycle of the control signal to adjust the conditioning of the electrical energy using the switch mode power conditioning circuitry, to regulate the operating point of the fuel cell.

2. The system of claim 1 wherein the switch mode power conditioning circuitry regulates the operating point of the fuel cell by maintaining the voltage output of the fuel cell within a predetermined range.

3. The system of claim 1 wherein the controller is configured to monitor the electrical status comprising a voltage of the fuel cell and to modify the duty cycle of the control signal responsive to the voltage of the fuel cell being below a threshold.

4. The system of claim 1 wherein the fuel cell power system comprises a plurality of fuel cells, and the controller is configured to monitor the electrical status comprising average voltage of one or more of the plurality of the fuel cells to monitor the fuel cells.

5. The system of claim 1 wherein the fuel cell power system comprises a plurality of fuel cells, and the switch mode power conditioning circuitry comprises a plurality of switch mode power conditioning circuits associated with respective ones of the fuel cells and wherein the controller is configured to monitor the electrical status of individual ones of the fuel cells and to control respective ones of the switch mode power conditioning circuits responsive to the monitoring.

6. The system of claim 5 wherein the controller includes sequencing circuitry configured to apply the control signal from the controller to the switch mode power conditioning circuits at different moments in time.

7. A fuel cell power system comprising:

a plurality of fuel cells configured to generate electrical energy;

switch mode power conditioning circuitry comprising an electrical energy storage device and a switch, wherein the switch mode power conditioning circuitry is electrically coupled to each fuel cell and configured to electrically condition the electrical energy generated by the fuel cells; and

a controller configured to monitor an electrical status of at least one of the fuel cells and to adjust the conditioning of electrical energy using the switch mode power conditioning circuitry responsive to the monitoring, wherein the controller is configured to provide a pulse width modulated control signal to control the switching and to vary a duty cycle of the control signal to adjust the conditioning of the electrical energy using the switch mode power conditioning circuitry, to regulate the operating point of the fuel cell.

8. The system of claim 7 wherein the switch mode power conditioning circuitry regulates the operating point of the fuel cell by maintaining the voltage output of the fuel cell within a predetermined range.

9. The system of claim 7 wherein the controller is configured to monitor the electrical status comprising voltage of at least one of the fuel cells and to modify the duty cycle of the control signal responsive to the voltage of the at least one fuel cell being outside a predetermined range to adjust the conditioning of electrical energy using the switch mode power conditioning circuitry.

10. The system of claim 7 further comprising a battery, and wherein the controller is configured to monitor a voltage of the battery and to adjust the duty cycle of the control signal responsive to the voltage of the battery being outside a predefined range.

11. A fuel cell power system comprising:

a plurality of fuel cells configured to generate electrical energy;

a plurality of switch mode power conditioning circuits respectively comprising an electrical energy storage device and a switch, wherein each switch mode power conditioning circuit is electrically coupled to one of the fuel cells and configured to electrically condition the electrical energy generated by the fuel cell coupled thereto; and

a controller configured to monitor an electrical status of at least one of the fuel cells and to adjust the conditioning of electrical energy using the switch mode power conditioning circuitry responsive to the monitoring, wherein the controller is configured to provide a pulse width modulated control signal to control the switching and to vary a duty cycle of the control signal to adjust the conditioning of the electrical energy using the switch mode power conditioning circuitry, to regulate the operating point of each fuel cell.

12. A fuel cell power system comprising:

a first bus;

a second bus;

a fuel cell coupled with the first bus;

switch mode power conditioning circuitry coupled intermediate the first bus and the second bus and comprising a switch and an electrical energy storage device, wherein the switch mode power conditioning circuitry is configured to condition electrical energy from the first bus and the fuel cell and to provide conditioned electrical energy to the second bus; and

a controller configured to provide a pulse width modulated control signal to control the switching of the switch mode power conditioning circuitry, to monitor an electrical status of the fuel cell and to vary a duty cycle of the control signal to adjust the conditioning of electrical energy using the switch mode power conditioning circuitry responsive to the monitoring.

13. The system of claim 12 wherein the switch mode power conditioning circuitry comprises a plurality of switch mode power conditioning circuits coupled in parallel with the second bus.

14. The system of claim 12 wherein the first bus comprises one or more busses, and wherein fuel cell power system comprises a plurality of fuel cells.

15. The system of claim 12 wherein the controller is configured to monitor the electrical status comprising voltage of the fuel cell and to modify the duty cycle of the control signal responsive to the voltage of the fuel cell being outside the predetermined range.

16. A fuel cell power system comprising:

a fuel cell configured to generate electrical energy;

switch mode power conditioning circuitry comprising a switch and an electrical energy storage device configured to electrically condition the electrical energy;

a battery electrically coupled with the switch mode power conditioning circuitry and configured to store electrical energy; and

a controller configured to monitor an electrical status comprising voltage of the battery, to provide a pulse width modulated control signal to control the switching of the switch mode power conditioning circuitry, and to vary the duty cycle of the control signal to adjust the conditioning of electrical energy using the switch mode power conditioning circuitry responsive to the monitoring to maintain the voltage of the battery within a defined range.

17. The system of claim 16 wherein the controller is configured to increase the duty cycle responsive to the voltage of the battery being below a first threshold and to decrease the duty cycle responsive to the voltage of the battery being above a second threshold.

18. The system of claim 16 wherein the fuel cell comprises a plurality of fuel cells, and the switch mode power conditioning circuitry comprises a plurality of switch mode power conditioning circuits associated with respective ones of the fuel cells, and the controller is configured to monitor individual ones of the fuel cells and to control respective ones of the switch mode power conditioning circuits responsive to the monitoring.

19. The system of claim 16 wherein the fuel cell comprises a plurality of fuel cells, and the switch mode power conditioning circuitry comprises a plurality of switch mode power conditioning circuits associated with respective ones of the fuel cells, and the controller comprises sequencing circuitry configured to apply a control signal to the switch mode power conditioning circuits at different moments in time.

20. The system of claim 16 wherein the controller is configured to monitor an electrical status of the fuel cell and to adjust the conditioning of electrical energy using the switch mode power conditioning circuitry responsive to the monitoring.

21. The system of claim 20 wherein the controller is configured to monitor the electrical status of the fuel cell comprising a voltage of the fuel cell, and to reduce a duty cycle of the control signal responsive to the voltage of the fuel cell being below a threshold.

22. A fuel cell power system comprising:
a plurality of fuel cells;

a plurality of switch mode power conditioning circuits individually including an energy storage device and a switch, the switch mode power conditioning circuits being configured to electrically condition electrical energy generated by the fuel cells; and

a controller configured to provide a plurality of pulse width modulated control signals to the switch mode power conditioning circuits to control the switching devices to monitor an electrical status of the fuel cells and to vary the duty cycles of the control signals to adjust the conditioning of electrical energy using the switch mode power conditioning circuits responsive to the monitoring.

23. The system of claim 22 wherein the controller is configured to monitor the electrical status comprising voltages of the fuel cells and to adjust at least one of the control signals responsive to the voltage of at least one of the fuel cells being outside a predetermined range.

24. The system of claim 22 further comprising a battery coupled with the switch mode power conditioning circuits, and wherein the controller is configured to monitor an operating condition of the battery and to adjust at least one of the control signals to maintain a voltage of the battery within a defined range.

25. The system of claim 22 wherein the controller includes a sequencing circuit coupled with the switch mode power conditioning circuits and configured to receive at least one of the control signals and to apply a first of the control signals to a first one of the switch mode power conditioning circuits at a first moment in time and to apply a second of

the control signals to a second one of the switch mode power conditioning circuits at a second moment in time after the first moment in time.

26. The system of claim 22 wherein the controller is configured to apply the control signals to the switch mode power conditioning circuits at different moments in time during a switching period.

27. The system of claim 22 wherein the switch mode power conditioning circuits are individually configured to condition electrical energy from respective ones of the fuel cells.

28. A method of operating a fuel cell power system comprising:
generating electrical energy using a fuel cell;
conditioning the electrical energy using switch mode power conditioning circuitry comprising a switch and an electrical energy storage device;
providing a pulse width modulated control signal to control the switch;
monitoring an electrical status of the fuel cell; and
adjusting the conditioning of the electrical energy using the switch mode power conditioning circuitry responsive to the monitoring, the adjusting comprising varying a duty cycle of the pulse width modulated control signal.

33. A method of operating a fuel cell power system comprising:
generating electrical energy using a fuel cell;
conditioning the electrical energy using switch mode power conditioning circuitry comprising an electrical energy storage device and a switch;
providing a pulse width modulated control signal to control the switching of the switch mode power conditioning circuitry;
monitoring an electrical status of the fuel cell; and
adjusting the conditioning of electrical energy using the switch mode power conditioning circuitry responsive to the monitoring, the adjusting comprising adjusting a duty cycle of the control signal.

34. The method of claim 33 wherein the monitoring comprises monitoring the electrical status comprising voltage of the fuel cell, and wherein the adjusting comprises reducing the duty cycle responsive to the voltage of the fuel cell being below a threshold.

35. The method of claim 33 wherein the generating comprises generating electrical energy using a plurality of fuel cells, and wherein the monitoring comprises monitoring the electrical status comprising an average voltage of the fuel cells.

36. The method of claim 33 wherein the generating comprises generating electrical energy using a plurality of fuel cells and the conditioning comprises conditioning using the switch mode power conditioning circuitry comprising a plurality of switch mode power conditioning circuits associated with respective ones of the fuel cells, and wherein

the monitoring comprises monitoring individual ones of the fuel cells and the adjusting comprises adjusting respective ones of the switch mode power conditioning circuits responsive to the monitoring.

37. The method of claim 33 wherein the generating comprises generating electrical energy using a plurality of fuel cells and the conditioning comprises conditioning using the switch mode power conditioning circuitry comprising a plurality of switch mode power conditioning circuits associated with respective ones of the fuel cells, and further comprising applying the control signal to the switch mode power conditioning circuits at different moments in time to control switches of the switch mode power conditioning circuits.

38. A method of operating a fuel cell power system comprising:
generating electrical energy using a fuel cell;
receiving electrical energy within a first bus coupled with the fuel cell;
conditioning the electrical energy from the first bus using a switch mode power conditioning circuit coupled in parallel with the first bus and a second bus, the switch mode power conditioning circuit including a switch and an electrical energy storage device;
supplying conditioned electrical energy to a load using the second bus;
providing a pulse width modulated control signal to control the switching of the switch mode power conditioning circuit;
monitoring an electrical status of the fuel cell; and
adjusting the conditioning of electrical energy using the switch mode power conditioning circuits responsive to the monitoring, the adjusting comprising adjusting a duty cycle of the control signal.

39. The method of claim 38 wherein the generating comprises generating using the fuel cell coupled in parallel with the first bus.

40. The method of claim 38 wherein the monitoring comprises monitoring the electrical status comprising a voltage of the fuel cell, and wherein the adjusting comprises reducing the duty cycle of the control signal responsive to the voltage of the fuel cell being below a threshold.

41. A method of operating a fuel cell power system comprising:

generating electrical energy using a fuel cell;

conditioning the electrical energy using switch mode power conditioning circuitry comprising a switch and an electrical energy storage device configured to electrically condition the electrical energy;

controlling the switch using a pulse width modulated control signal;

storing electrical energy within a battery;

monitoring a voltage of the battery; and

adjusting the conditioning of the electrical energy using the switch mode power conditioning circuitry responsive to the monitoring of the voltage of the battery, the adjusting comprises increasing a duty cycle of the control signal responsive to the voltage of the battery being below a first threshold and decreasing the duty cycle responsive to the voltage of the battery being above a second threshold; and

providing electrical energy from the switch mode power conditioning circuitry and the battery to a load.

42. The method of claim 41 further comprising:

monitoring an electrical status of the fuel cell; and

adjusting the conditioning of the electrical energy using the switch mode power conditioning circuitry responsive to the monitoring of the electrical status of the fuel cell.

43. The method of claim 42 wherein the monitoring comprises monitoring the electrical status comprising a voltage of the fuel cell, and the adjusting comprises reducing a duty cycle of the control signal responsive to the voltage of the fuel cell being below a threshold.

44. The method of claim 41 wherein the adjusting comprises adjusting to maintain the electrical status of the battery within a predetermined range.

45. The method of claim 41 wherein the generating comprises generating electrical energy using a plurality of fuel cells and the conditioning comprises conditioning using the switch mode power conditioning circuitry comprising a plurality of switch mode power conditioning circuits associated with the fuel cells, and further comprising applying a control signal to the switch mode power conditioning circuits at different moments in time to control switches of the switch mode power conditioning circuits.

46. A method of operating a fuel cell power system comprising:
generating electrical energy using a plurality of fuel cells;
conditioning the electrical energy of the fuel cells using a plurality of switch mode power conditioning circuits individually including an electrical energy storage device and a switch; and
providing a plurality of control signals to the switch mode power conditioning circuits during a switching period to control the respective switches, wherein the providing the control signals comprises applying the control signals to the switch mode power conditioning circuits at different moments in time during the switching period.

47. The method of claim 46 wherein the providing comprises providing a common signal and sequencing the common signal to provide the plurality of control signals.

48. The method of claim 46 wherein the providing comprises providing the control signals comprising a plurality of different control signals, and sequencing the different control signals.

49. The method of claim 46 wherein the conditioning electrical energy comprises conditioning electrical energy of the fuel cells using the switch mode power conditioning circuits associated with respective ones of the fuel cells.

50. The method of claim 46 further comprising:
monitoring an electrical status of the fuel cells; and
adjusting the control signals responsive to the monitoring.

51. The method of claim 50 wherein the providing comprises providing the control signals comprising pulse width modulated control signals and the adjusting comprises adjusting duty cycles of the control signals.

52. The method of claim 50 wherein the monitoring comprises monitoring the electrical status comprising individual voltages of the fuel cells, and the adjusting comprises reducing a duty cycle of one of the control signals responsive to the voltage of the respective fuel cell being outside a predetermined range.

53. The method of claim 50 wherein the monitoring comprises monitoring the electrical status comprising individual voltages of the fuel cells, and the adjusting comprises reducing duty cycles of the control signals responsive to the voltages of the respective fuel cells being below a threshold.

54. The method of claim 46 further comprising:
providing electrical energy to a battery coupled with the switch mode power conditioning circuits;
monitoring an electrical status of the battery; and
adjusting the control signals responsive to the monitoring to maintain the electrical status of the battery within a range.

14
SCANNED. #